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Special Wires and Needles for Tendon Sutures.

The invention pertains to steel wires armed with barbs and spiral needles for tendon suture, which, other than the simplification of the suturing technique compared to the conventional methods, avoid multiple piercing of the tendon surface, and also the remaining of suture sections and/or hooks on the outside of the tendon, which conventionally affects the functional result of the intervention due to the coalescence of the tendon with its surroundings.

As a rule, tendons are sutured with very thin steel wire that either remains in the tissue or is removed after approximately three weeks with the help of a separate extraction wire, for example as in the extraction suture according to BUNNELL, which is especially advantageous in the case of injuries of the flexor tendons in the *manus cava*. Because the tendon consists of individual longitudinal fiber bundles that are only loosely connected with each other, a simple suture in case of longitudinal cleavage of the tendon would tear out, for which reason especially thicker tendons, which are exposed to a correspondingly greater muscle tension, must be sutured in such a manner that the suture does not include the loose connective tissue between the longitudinal fibers, but instead loops around the actual fiber bundles, i.e. the suture must more or less spirally intertwine at least the proximal tendon stump:

In the case of the most commonly used suturing technique according to BURNELL, the tendon stump is first pierced and next the two ends of the wire, both armed with a needle, are placed opposite to one another and obliquely through the tendon, so that both cross each other twice in the tendon and emerge from the sectional plane of the tendon. On the other hand, the tendon suture according to LENGEMANN is easier to perform; in this case the tendon stump must be pierced only once in longitudinal direction and is kept in place by a v-shaped double hook that rests on the tendon.

Besides the less favorable prognosis for tractor tendons compared to flexor tendons, the functional result of a tendon suture is dependent not only on the fact that the suture in the tendon is kept in place and adjusts well and without tension to the refreshed section plane, but to an equal extent is also determined by the fact that no coalescences can occur with the surrounding area, that would impede the restoration of the sliding capacity of the tendon despite pertinent post-treatment. Of course, the danger of such coalescences is reduced when the smooth surface of the tendon is not affected by sutures or traumatizing retention instruments.

However, as a rule tendon sutures require multiple piercing of the tendon surface, whereby the outermost steel wire minimally provokes a punctiform scar connection between the tendon and the surrounding tissue as a result of tissue reaction. The same applies in the case of the hook placed on the tendon, when the special wire according to LENGEMANN is used.

For that reason, special wires or a special needle for use with conventional steel wire are recommended, with which the tendon suture can be performed using a simple technique while the normally occurring trauma to the tendon surface can be avoided.

Figure 1 A shows a wire armed on both sides with a needle with at least two small barbs, which are pulled up from the section plane in the proximal stump, so that they are not located in the interior of the tendon in contrast with the suturing technique according to LENGEMANN. A monofil wire can thereby be provided with such barbs by means of variously arranged small pins (Figure 1 B and C) , as well as through oblique incisions D or corresponding compression moulds, whereby a non-rounded wire cross-section, for example triangular or ribbon-shaped, would not only counteract the turning of the wire in the tendon, but can, for example, be better adapted to a correspondingly ribbon-shaped tendon. In the case of polyfil wires, barbs can be produced by a corresponding bending of individual wires or wire loops. In addition, all barbs should possess little elasticity so that they will expand in case of tractive force in one direction and narrow in the event of the opposite tractive force, in order to enhance their stability in the tendon and to facilitate the removal of the wire after three weeks.

Figure 2 shows the use of two such barbs in the form of a pull-out suture.

For the relatively rare instance in which the distal tendon stump must be more strongly fixed, wires are indicated with at least one barb for both tendon stumps (Figure 3A and B), whereby subsequent removal of such a wire is possible only if the connection of the barbs over the suture location can be eliminated from the outside, which can be achieved through a rated breaking point *a* or a tiny thread *b*, whereby the twisting of the two wire ends in the opposite direction loosens the connection. As shown in Figure 3 A and B, the barbs must be placed on the wire in the form of a ring, in order to prevent that barbs turn when the wire is removed.

The wire in Figure 3 G has non-turning barbs whose connection over the suture site is achieved by means of two fitted tiny loops *c*, that are locked by the end of an additional third wire that releases the connection when it is pulled out.

In addition, consideration can be given to the possibility of slowly resorbing barbs (chrome catgut) on a steel wire to be removed after three weeks Figure 3 D. [sic] However, in this case the center wire must have such a stability that the proximal tendon stump can be pushed over the barbs. A second needle was not used in this instance, in order to avoid traumatizing penetration at the tendon surface of the proximal stump.

Although the barb connection in Figure 3 E, made of correspondingly stable steel wire for the piercing of the tendon stump, or also slowly resorbing material, cannot be pulled from the tendon, any penetration of the tendon surface is avoided.

On the other hand, the spiral needles in Figure 4 permit not only an essentially simplified placement of crossed spiral sutures according to the type of the BUNNELL suture, and

also avoid the conventionally required multiple piercing of the tendon surface and the trauma to externally located suture segments.

The suture is placed (Figure 5) by first inserting a spiral needle from the section plane through the proximal end of the stump after which the needle is armed with a suture, whereby the atraumatic wire of the [patent] applicant is recommended, which by cutting the diameter at the tip in half prevents the doubling of the wire gauge in the eye of the needle. When the needle is turned back, the wire is pulled in a single operation into the spiral piercing channel. Similar to the BUNNELL suture, the other end of the wire is then drawn into the tendon stump in a similar manner, but in opposite direction, using the second spiral needle that presents a thread in the opposite direction.

Figure 6 shows that the course of the wire of the applied extraction suture corresponds in principle to the suture technique according to BUNNELL, whereby, other than the lesser trauma to the tendon surface and the simpler placement of the suture, the exactly spiral course especially offers the advantage that the wire does not rest on the loose interstitial tissue but rather on the surrounded longitudinal fiber bundle.

Patent Claims:

Special wires and needles for tendon suture characterized by the fact that:

1.) A steel wire armed in the conventional manner on both sides with a needle presenting a round, triangular or ribbon-shaped cross-section presents in a short middle segment one or several barbs pointing in the same direction.

2.) The wire for tendon suture presents on both sides of the middle at least one barb each that can turn on the wire and is immovable in the longitudinal direction, pointing in the opposite direction, whereby the wire segment between the two barbs presents a rated breaking point that can be twisted off, for example by narrowing the wire or dividing the wire in two.

3.) According to Claim 2, characterized by the fact that the twist-off rated breaking point is replaced by a small thread.

4.) That a tendon wire presents in the middle at least two barbs directed towards each other whereby the bond of the connecting piece is achieved by means of two small, stacked loops locked by the end of a separate wire.

5.) That a tendon wire armed on only one side with a needle presents on the opposite side a somewhat stronger longitudinal stability and on both sides is equipped with barbs with different directions made of a slowly resorbing material.

6.) That a connection piece pointed on both sides with a round or ribbon-shaped cross-section possesses on both halves barbs pointing in opposite direction, and made of stainless steel or a slowly resorbing material.

7.) That a needle for the placement of a tendon suture with conventional steel wire is bent in spiral form at minimally 1 ½ bends and presents at the tip a closed or open eye of the needle and at the end a bend or a widened grip end.

8.) According to Claims 1-7 characterized by the fact that wires and needles have been previously sterilized and are packaged in a sterile manner.

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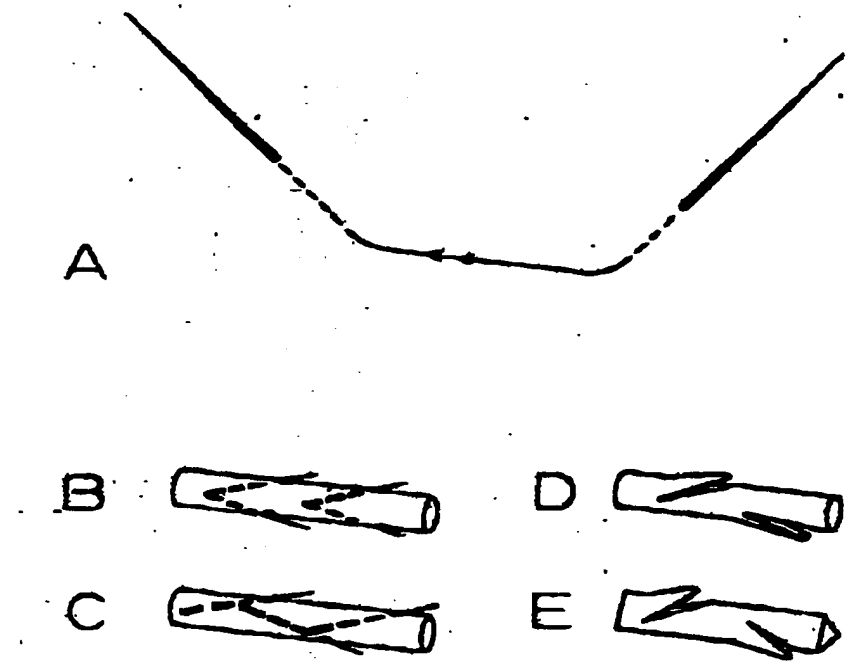

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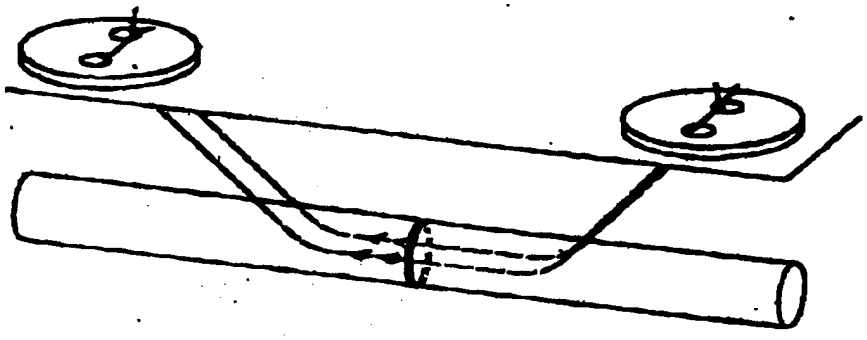

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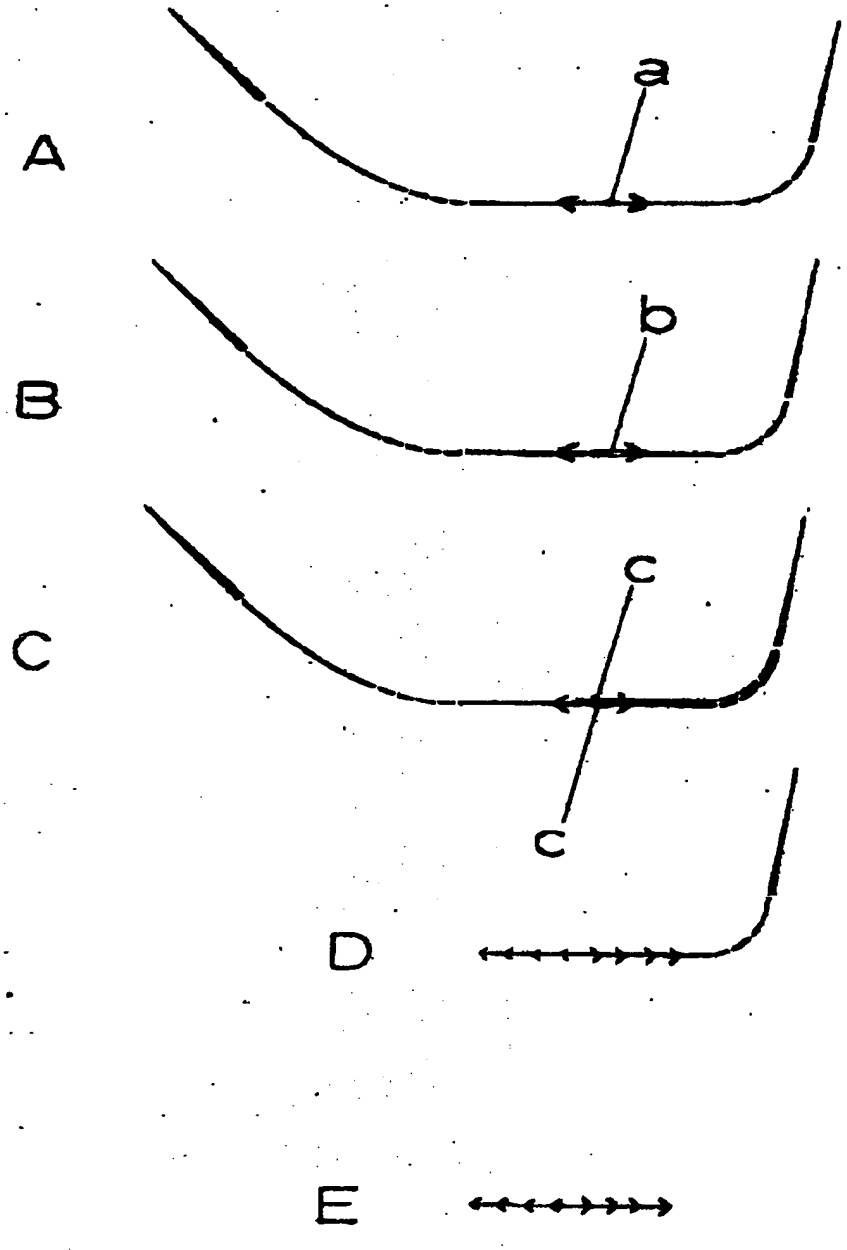

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